Annex B

Woodhead Publishing in Food Science and Technology

# Handbook of hydrocolloids

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CRC

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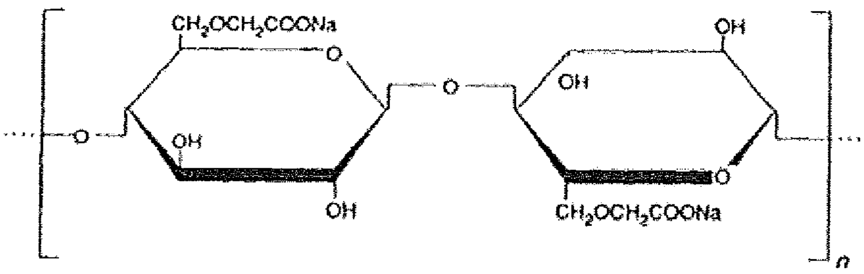


**Fig. 12.2** Idealised unit structure of cellulose gum, with a ds of 1.0.

average chain length or degree of polymerisation of the cellulose molecules (dp) and thirdly, the degree of substitution of the chain. Additionally, the particle size of the hydrocolloid may be varied. Particle size and powder bulk density affect the dissolving characteristics of the product. Granular material is less prone to clumping or balling but takes longer to dissolve. Fine powdered material can give very rapid hydration, but does not disperse so easily and good stirring or blending techniques are necessary. Degree of polymerisation is a measure of the chain length of the polymer. Increasing dp very rapidly increases the viscosity of the modified cellulose in solution, although the viscosities of two differently substituted modified celluloses of comparable dp will not necessarily be comparable.

In general the modified celluloses give neutral-flavoured, odourless and colourless clear solutions. It should be noted that all modified celluloses, in powder or even granular form, are capable of absorbing water from the atmosphere. It is therefore desirable to store these products in airtight packs.

### 12.4.2 Methyl cellulose and hydroxypropyl methyl cellulose

The properties of these two hydrocolloids are very similar and will be covered together. Mc and hpmc are both soluble in cold water to give solutions with a wide range of viscosity, which is dependent on both dp and ds. These solutions show reasonable viscosity stability over the range pH3–11. More important, however, is the behaviour of solutions on heating since the solution will change into a gel once the temperature of the solution has been raised above a point known as the incipient gel temperature (igt). The igt varies from 52°C for mc, to a range of 63–80°C for hpmc types with increasing degree of hydroxypropyl substitution increasing the igt. These gels are reversible on cooling although there is a pronounced hysteresis between heating and cooling. Both polymers are good film formers and also exhibit some surface activity. Commercially mc and hpmc are distinguished by viscosity in 2% aqueous solutions, and also by the ds.

### 12.4.3 Hydroxypropyl cellulose

Hpc is also soluble in cold water and again a range of viscosity can be obtained dependent on dp. Hpc becomes insoluble at temperatures above approximately 45°C but unlike mc and hpmc, no gel is formed. Hpc is unusual in food hydrocolloids in that it is soluble in ethanol and mixtures of ethanol and water. However, the most interesting properties of hpc are probably its good film formation and its high surface activity compared to most other hydrocolloids. Commercially, the various grades of hpc for food use are differentiated by viscosity.

### 12.4.4 Methylethyl cellulose

In common with mc or hpmc, mec is also soluble in cold water and forms gels on heating, albeit weak gels, above the igp. These properties alone would not justify great interest in mec as a food additive, rather it is its surface activity and consequent excellent performance as a whipping aid, particularly in the presence of protein, which are of technical use.

### 12.4.5 Carboxymethyl cellulose

*General*

Cmc is soluble in both hot and cold water to give clear and colourless solutions with neutral flavour. As with other modified celluloses, the solution viscosity depends on dp, but it is possible to produce 1% aqueous solutions with viscosity of 5,000 mPas at ambient temperatures. These solutions do show a reversible reduction of viscosity on heating but in food systems do not gel either alone or with other hydrocolloids. The rate of viscosity build-up is obviously dependent on dp, particle size and to some extent on ds. With suitable fine grind powders an extremely rapid viscosity development can be obtained.

A maximum degree of substitution of 1.5 is permitted in a recent amendment to EU legislation, but more typically ds is in the range 0.6–0.95 for food applications. ds, together with the uniformity of substitution, affects the rheology of the solution. Solutions of lower ds are thixotropic, whereas higher ds tends to pseudoplasticity. Uniformity of substitution favours pseudoplastic rheology, and solutions of such types give a particularly 'smooth' mouthfeel.

Commercially, cmc types are distinguished by viscosity, by particle size and to a more limited extent by ds and special solution characteristics. It is necessary to check the concentration of the solutions for which viscosities are specified, as there is not a single standard value for concentration.

*Interaction of cmc with proteins*

Cmc is an ionic polymer and this allows the formation of complexes with soluble proteins such as casein and soy at, or around, the isoelectric region of the protein. Although the effect on the system is primarily dependent on pH, it is also dependent on the composition and concentration of the protein, temperature, and the concentration and type of the cmc. At pH less than 3.0 or higher than 6.0, cmc reacts in the cold with the proteins in milk to form a complex, which can be removed as a precipitate. In the pH range approximately 3.0–5.5, a stable complex is formed. At the maximum of stability the viscosity is abnormally high compared to the individual components. A representation of the effects of pH on the viscosity of a solution of cmc and casein is shown in Fig. 12.3.

The system containing the cmc and casein complex is relatively shear sensitive, and the viscosity decreases under agitation. The complex is heat stable and little viscosity decrease is observed on heating. The casein is denatured to a much smaller extent than would be the case in the absence of cmc.

## 12.5 Applications

### 12.5.1 Methyl cellulose and hydroxypropyl methyl cellulose

The major applications of these two hydrocolloids are in the fields of binding and shape